
Two New Combinations in *Arisaema* (Araceae) from India

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ABSTRACT. Taxonomic and palynological studies on *Arisaema* Martius (Araceae) from the Western Ghats, India, distinguish two taxa belonging to section *Tortuosa* Engler. *Arisaema sahyadricum* S. R. Yadav, K. S. Patil & Bachulkar var. *ghaticum* Sardesai, S. P. Gaikwad & S. R. Yadav, a recently described variety in 2006, is treated here at the species level as *A. ghaticum* Punekar & Kumaran. *Arisaema sivadasanii* S. R. Yadav, K. S. Patil & Janarthanam, previously considered as a synonym of *A. tortuosum* (Wallich) Schott, is recognized here as the subspecies *A. tortuosum* subsp. *sivadasanii* (S. R. Yadav, K. S. Patil & Janarthanam) Punekar & Kumaran. Taxonomic implications are discussed and a key to the *Arisaema* taxa of the North Western Ghats is provided.

Key words: Araceae, *Arisaema*, India, IUCN Red List, pollen morphology.

The genus *Arisaema* Martius (Araceae) comprises ca. 170 species (Mayo et al., 1997), 210 species (Govaerts & Frodin, 2002), or ca. 150 species (Gusman & Gusman, 2002). In addition, Govaerts and Frodin (2002) recognized nine subspecies and 24 varieties, while Gusman and Gusman (2002) recognized 12 subspecies, eight varieties, and two forms. The genus extends from Central and East Africa to Southeast Asia, including Yemen, Oman, Pakistan, Afghanistan, the Himalayan ranges, and India, as well as China, Korea, Japan, Siberia, and into North America. In India, the genus has 44 species and nine varieties (Karthikeyan et al., 1989), 38 species and six varieties (Govaerts & Frodin, 2002), or 36 species, one subspecies, one variety, and one form (Gusman & Gusman, 2002). At present, the North Western Ghats in India have six species, one subspecies, and two varieties (including the combinations herein), of which three taxa are endemic to this area, i.e., *A. ghaticum* Punekar & Kumaran, *A. murrayi* (J. Graham) Hooker var. *sonubeniae* P. Tetali, Punekar & Lakshminarasimhan, and *A. sahyadricum* S. R. Yadav, K. S. Patil & Bachulkar (Punekar & Kumaran, 2005). During floristic studies on the genus *Arisaema* of the North Western Ghats, an interesting *Arisaema* was collected, which, after study of relevant literature (Engler, 1920; Sivadasan, 1982; Yadav et al., 1993, 1997; Lakshminarasimhan, 1996; Sasikala, 2000;

Mishra & Singh, 2001; Gusman & Gusman, 2002; Tetali et al., 2004; Sardesai et al., 2006), comparison with herbarium collections at BSI and CAL, and our own field observations, was identified as the recently described *A. sahyadricum* var. *ghaticum* Sardesai, S. P. Gaikwad & S. R. Yadav (2006). However, these plants that are referable to *A. sahyadricum* var. *ghaticum* should be recognized at the specific level, as the taxon differs from the allied species *A. murrayi* and *A. sahyadricum* (Figs. 1C, D; 2C, D) in many characters, including spathe color, the slender appendage that is well exerted and curved downward and back again, and pollen morphology. Comparison of morphological and pollen characters of *A. ghaticum* with its allied species is provided in Table 1.

Materials used in the present study were collected from the Sinhagad, Mahabaleshwar, and Amboli areas in the North Western Ghats. Voucher specimens are deposited at the Herbarium of the Agharkar Research Institute, Pune, India (AHMA). Voucher material for pollen studies may be found at the repository of the Paleobiology Group, Agharkar Research Institute, Pune, India (Palaeo. Agharkar Res. Inst.).

Pollen grains for SEM study were collected from fresh anthers and prepared by the method proposed by Juniper et al. (1970) with slight modifications. Pollen grains were fixed with 2% glutaraldehyde, rinsed in distilled water, and then dehydrated through an acetone series. This was followed by critical-point drying, gold coating (JFC-1600 Auto Fine Coater; JEOL Datum Ltd., Tokyo, Japan), and examination under a JEOL-6360A analytical scanning electron microscope (JEOL Datum Ltd.) in the Department of Physics, University of Pune. The terminology applied for pollen grains generally follows that of Erdtman (1966) and Kremp (1968).

NEW COMBINATIONS IN *ARISAEMA*

1. ***Arisaema ghaticum*** (Sardesai, S. P. Gaikwad & S. R. Yadav) Punekar & Kumaran, comb. et stat. nov. Basionym: *Arisaema sahyadricum* S. R. Yadav, K. S. Patil & Bachulkar var. *ghaticum* Sardesai, S. P. Gaikwad & S. R. Yadav, Rheede 16: 45. 2006. TYPE: India. Maharashtra: Kas, 26

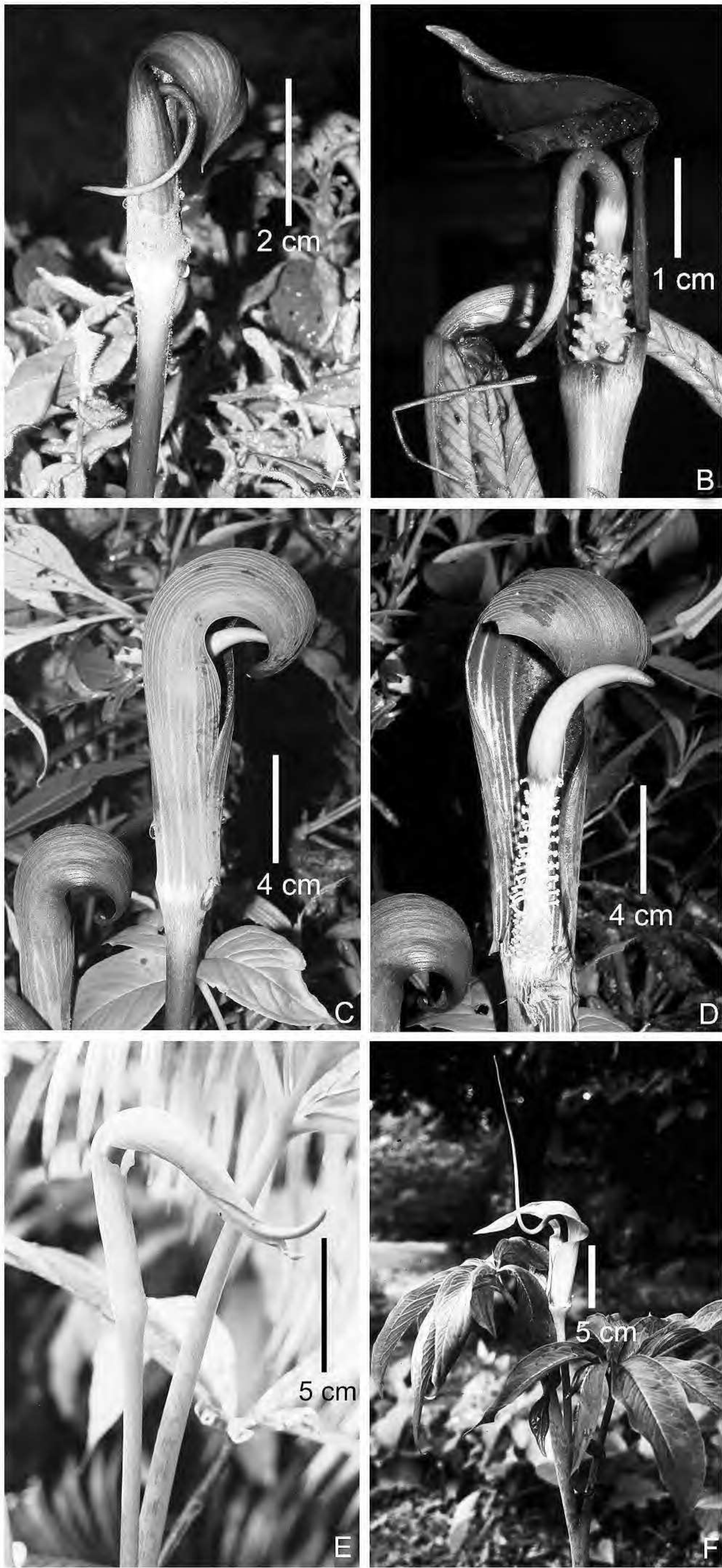


Figure 1. A, B. *Arisaema ghaticum* (Sardesai, S. P. Gaikwad & S. R. Yadav) Punekar & Kumaran. —A. Inflorescence. —B. Spathe cut open to show androgynous spadix. C, D. *A. sahyadricum*. —C. Inflorescence. —D. Spathe cut open to show androgynous spadix. —E. *A. tortuosum* subsp. *sivadasanii* (S. R. Yadav, K. S. Patil & Janarthanam) Punekar & Kumaran, inflorescence. —F. *A. tortuosum* subsp. *tortuosum*, inflorescence. Photos by S. A. Punekar.

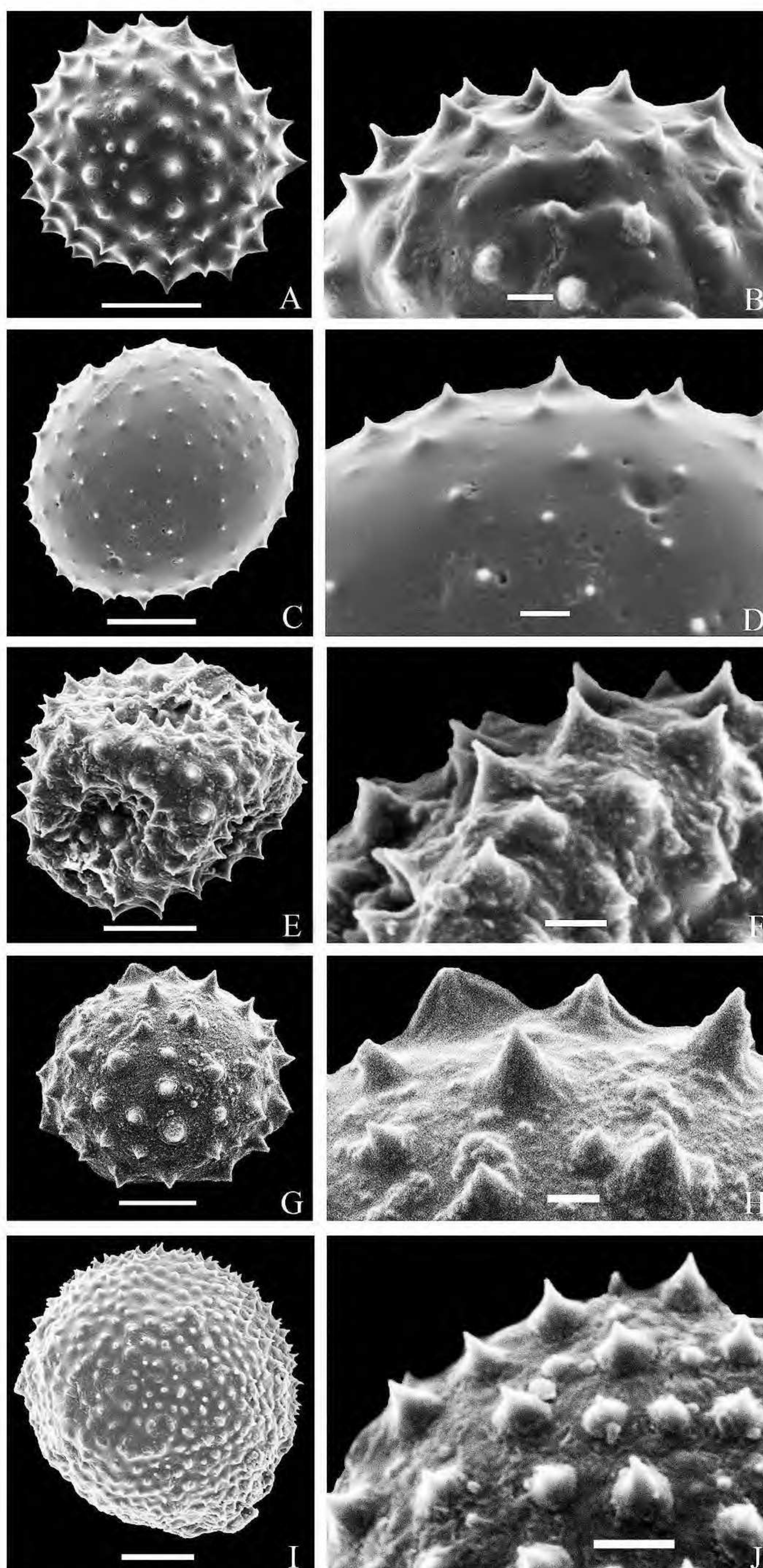


Figure 2. SEM image of pollen. A, B. *Arisaema ghaticum* (Sardesai, S. P. Gaikwad & S. R. Yadav) Punekar & Kumaran. —A. Pollen. —B. Enlarged sector showing the echinae. C, D. *A. sahyadricum*. —C. Pollen. —D. Enlarged sector showing the echinae. E, F. *A. tortuosum* var. *tortuosum*. —E. Pollen. —F. Enlarged sector showing the echinae. G, H. *A. tortuosum* var. *neglectum*. —G. Pollen. —H. Enlarged sector showing the echinae. I, J. *A. tortuosum* subsp. *sivadasanii* (S. R. Yadav, K. S. Patil & Janarthanam) Punekar & Kumaran. —I. Pollen. —J. Enlarged sector showing the echinae. Scale bars: A, C, E, G, I = 5 μ m; B, D, F, H, J = 1 μ m.

Table 1. Comparative morphological characters of *Arisaema ghaticum* with its allied species.

	<i>A. ghaticum</i>	<i>A. sahyadricum</i>	<i>A. murrayi</i>
Inflorescence	emergence before the leaves unfold	emergence along with leaf	emergence before the leaves unfold
Spathe	≤ 6 cm	7–13 cm	6.5–15 cm
Spathe tube	mauve to greenish brown, without any vertical white striations	reddish purple, with white vertical striations	green entirely or in lower half, white or purple in upper half, with paler longitudinal stripes
Spathe limb	curved downward, mauve to greenish brown, without any vertical white stripes	curved downward, reddish purple with pale stripes	almost at right angles to spathe tube, white, light purple, or lavender with translucent veins and a cherry-red cross band at the base inside
Appendix	well exerted from spathe, curved downward and back again	included in spathe, curved	included in spathe, curved, S-shaped
Anther	anther connectives with 2 to 4 elongated, conical processes	anther connectives with 2 to 4 elongated, conical processes	anther connectives without any processes
Pollen	echinae or spinules comparatively dense, ca. 8 per 5 μm ² , pollen surface psilate, undulating	echinae or spinules sparse, ca. 6 per 5 μm ² , pollen surface psilate	echinae or spinules sparse, ca. 4 to 6 per 5 μm ² , pollen surface psilate or perforate

May 1997, *M. M. Sardesai* 394 (holotype, CAL; isotypes, BLAT, BSI, CALI, K, Dept. Bot. Shivaji Univ., Kolhapur). Figures 1A, B; 2A, B.

Distribution and habitat. At Sinhagad, the plants grow at altitudes of 1200–1400 m in rock crevices, near boulders, on steep grassy hillsides, and also in well-exposed soil-covered basaltic plateaus in association with *Arisaema murrayi*, *Begonia concanensis* A. DC., *Curculigo orchiodes* Gaertner, *Heracleum grande* (Dalzell & A. Gibson) P. K. Mukhopadhyay, *Hypoxis aurea* Loureiro, *Impatiens dalzellii* Hooker f. & Thomson, *Sonerila scapigera* Dalzell, and *Typhonium venosum* (Dryander ex Aiton) Hetterscheid & P. C. Boyce. It has been observed in Sinhagad that an unidentified snail species forages only on reproductive parts like the spathe, spadix, and appendage, causing a natural threat to the population of *A. ghaticum*. At the Kas Plateau, it grows in association with *A. murrayi*, *Ceropegia jainii* Ansari & B. G. Kulkarni, *Curculigo orchiodes*, *Curcuma neilgherrensis* Wight, *Hypoxis aurea*, *Iphigenia stellata* Blatter, *Ledebouria revoluta* (L. f.) Jessop, and *Peristylus densus* (Lindley) Santapau & Kapadia. The population at Mahabaleshwar grows at an altitude of 1100–1200 m in shady roadside trenches on the outskirts of semi-evergreen forests dominated by *Catunaregam spinosa* (Thunberg) Tirvengadam, *Memecylon umbellatum* Burman f., and *Syzygium cumini* (L.) Skeels.

Phytogeography and endemism. The species is locally endemic in the North Western Ghats from Sinhagad to the Mahabaleshwar region.

IUCN Red List category. The population size is estimated to be fewer than 250 mature individuals, while the population at each location mentioned above is likely to contain fewer than 50 mature individuals. This population is currently under severe threat due to decline in quality of habitat (habitat conversion, construction of windmills on lateritic plateau, road widening, and landslides) and herbivores. If such threats continue, the population size may be reduced to less than 80% within the next 10 years. Therefore, after applying IUCN (2001) criteria, the species is categorized as Critically Endangered (CR).

Phenology. Flowering starts usually in mid-May or in the first week of June (as soon as the mist sets on the hills during the pre-monsoon showers); fruiting extends from June to July.

Relationships. *Arisaema ghaticum* is allied to *A. murrayi* and *A. sahyadricum* and clearly belongs to section *Tortuosa* Engler (sensu Murata, 1984, 1990) because of its lamellate spadix appendix and 5-carpellate ovaries. A comparative account of morphological and pollen characters is given in Table 1.

Representative specimens examined. INDIA. **Maharashtra:** Pune Distr., Sinhagad peak, *S. A. Punekar* 188635 (AHMA, BSI), *S. A. Punekar* 4703, 4709 (Paleobio. Agharkar Res. Inst.); Satara Distr., Mahabaleshwar to Ambenali Ghat rd., Met-tale village, *S. P. Kavade* & *S. A. Punekar* 188685 (Paleobio. Agharkar Res. Inst.), *S. A. Punekar* 4857 (Paleobio. Agharkar Res. Inst.).

2. *Arisaema tortuosum* (Wallich) Schott subsp. *sivadasanii* (S. R. Yadav, K. S. Patil &

Table 2. Comparative morphological characters of *Arisaema tortuosum* subsp. *sivadasanii* with its allied taxa.

	<i>A. tortuosum</i> subsp. <i>sivadasanii</i>	<i>A. tortuosum</i> var. <i>tortuosum</i>	<i>A. tortuosum</i> var. <i>neglectum</i>
Leaf	solitary	2	solitary
Inflorescence	emergence after the leaf, not overtopping the leaf	emergence after the leaf, overtopping the leaf	emergence along with leaf, not overtopping the leaf
Appendix	short, thick, projects only slightly out of the spathe limb	longer and long-exserted out of the spathe limb tapering like a sigmoidally curved rat tail	longer and long-exserted out of the spathe limb tapering like a sigmoidally curved rat tail
Pollen	echinae or spinules comparatively dense, ca. 20 per 5 µm ² , having bulbous base	echinae or spinules sparse, ca. 6 per 5 µm ² , having bulbous base	echinae or spinules sparse, ca. 4 to 6 per 5 µm ² , without bulbous base

Janarthanam) Punekar & Kumaran, comb. et stat. nov. Basionym: *Arisaema sivadasanii* S. R. Yadav, K. S. Patil & Janarthanam, Aroideana 20: 53. 1997 [1998]. TYPE: India. Maharashtra: Amboli, 10 Sep. 1995, S. R. Yadav 4688 (holotype, CAL; isotype, Dept. Bot. Shivaji Univ., Kolhapur not seen). Figures 1E; 2I, J.

Gusman and Gusman (2002) treated *Arisaema sivadasanii* as a synonym of *A. tortuosum* and considered it a late-flowering (from August to October) South Indian form of the polymorphic species *A. tortuosum*. Although morphological characters generally show that *A. tortuosum* subsp. *sivadasanii* is similar to *A. tortuosum* var. *tortuosum* and *A. tortuosum* var. *neglectum* (Schott) Fischer, it differs in having a short thick appendage that projects only slightly from the spathe limb (Fig. 1E) and by its late, prolonged flowering. It also differs from *A. tortuosum* var. *tortuosum* in possessing a usually solitary leaf. In varieties *tortuosum* and *neglectum*, the appendage is longer and long-exserted tapering like a sigmoidally curved rat tail (Fig. 1F). Palynologically, too, there are differences in the pollen exine structure and sculpture (Fig. 2E–J).

Distribution and habitat. This subspecies grows along roadsides in the shade of semi-evergreen forests in association with *Allophylus cobbe* (L.) Raeuschel, *Arisaema sahyadricum*, *A. tortuosum* var. *tortuosum*, *Dimorphocalyx ramiflorus* (J. Graham) M. R. Almeida, *Gynura biflora* (Burman f.) Merrill, *Luvunga eleutherandra* Dalzell, and *Mallotus stenanthus* Müller Argoviensis.

Phytogeography and endemism. This subspecies is so far known to be endemic to the North Western Ghats, from Chandoli Wildlife Sanctuary in Maharashtra to Molem National Park in Goa State.

IUCN Red List category. This subspecies has an area of occupancy estimated to be less than 20,000 km², with a severely fragmented population at fewer than 10 locations. The population size is estimated to be fewer than 10,000 mature individuals, and no subpopulation is estimated to contain more than 1000 mature individuals. This population is currently under severe threat due to decline in quality of habitat (habitat conversion and road widening) and forest management operations like weeding. If such threats continue, the population size may be reduced to a greater extent in the near future. Therefore, after applying IUCN (2001) criteria, the subspecies is categorized as Vulnerable (VU).

Phenology. Flowering season ranges from August to October; fruiting extends from late October to November.

Relationships. *Arisaema tortuosum* subsp. *sivadasanii* is allied to *A. tortuosum* var. *tortuosum* and *A. tortuosum* var. *neglectum* (all belong to section *Tortuosa*). A comparative account of morphological and pollen characters is given in Table 2.

Representative specimens examined. INDIA. **Maharashtra:** Amboli, S. R. Yadav 4695B (BSI); Amboli to Chokul rd., S. A. Punekar 5110 (Palaeobio. Agharkar Res. Inst.).

KEY TO THE TAXA OF *ARISAEMA* OF THE NORTH WESTERN GHATS

- 1a. Appendage well exserted from the spathe.
 - 2a. Flowering commences before leaves appear; appendage curved downward and back again *A. ghaticum*
 - 2b. Flowering commences only after leaves appear; appendage sigmoidally curved upward or S-curved.
 - 3a. Leaves usually 2; inflorescence overtopping the leaves *A. tortuosum* var. *tortuosum*
 - 3b. Leaf solitary; inflorescence not overtopping the leaf.
 - 4a. Appendage long (17–19.5 cm), thinner (0.4–0.5 cm), far exserted beyond the spathe limb, tapered sigmoidally *A. tortuosum* var. *neglectum*
 - 4b. Appendage short (10–15 cm), thicker (0.8–1 cm), slightly projecting out of the spathe limb, S-shaped *A. tortuosum* subsp. *sivadasanii*
- 1b. Appendage included within the spathe.

- 5a. Leaflets radiate; appendage included in spathe tube, rounded at apex.
- 6a. Inflorescence not overtopping the leaf; spathe without white or purple stripes; appendage smooth at apex *A. caudatum* Engler
- 6b. Inflorescence overtopping the leaf; spathe striped externally with white or purple; appendage rugose at apex *A. leschenaultii* Blume
- 5b. Leaflets pedate; appendage exerted from spathe tube, tapering at apex.
- 7a. Appendage thick (0.4–1 cm); anther connectives with 2 to 4 elongated, conical processes . . . *A. sahyadricum*
- 7b. Appendage thin (0.3–0.5 cm); anther connectives without processes.
- 8a. Spathe tube cylindric, green with paler longitudinal stripes becoming white near the mouth; limb white with a cherry-red cross band at the base inside; appendix green suffused with purple *A. murrayi* var. *murrayi*
- 8b. Spathe tube tapered, purple-lavender in upper half with scarlet blotch at the base on the anterior side; limb pale purple-lavender, appendix dark purple in lower half and white in upper half *A. murrayi* var. *sonubeniae*

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Literature Cited

Engler, A. 1920. Araceae–Aroideae und Areceae–Pistioideae. Pp. 1–274 in A. Engler (editor), *Das Pflanzenreich IV-23F* (Heft 73). W. Engelmann, Berlin.

Erdtman, G. 1966. *Pollen Morphology and Plant Taxonomy*. Angiosperms. Hafner, New York.

Govaerts, R. & D. G. Frodin (editors). 2002. *World Checklist and Bibliography of Araceae (and Acoraceae)*. Royal Botanic Gardens, Kew, Richmond.

Gusman, G. & L. Gusman. 2002. *The Genus Arisaema: A Monograph for Botanists and Nature Lovers*. Timber Press, Portland.

IUCN. 2001. *IUCN Red List Categories and Criteria, Version 3.1*. Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland, and Cambridge, United Kingdom.

Juniper, B. E., G. C. Cox, A. J. Gilchrist & P. R. Williams. 1970. *Techniques for Plant Electron Microscopy*. Blackwell Scientific Publications, Oxford.

Karthikeyan, S., S. K. Jain, M. P. Nayar & M. Sanjappa. 1989. *Florae Indicae Enumeratio: Monocotyledonae*. Botanical Survey of India, Calcutta.

Kremp, G. O. W. 1968. *Morphologic Encyclopedia of Palynology*. University of Arizona Press, Tucson.

Lakshminarasimhan, P. 1996. Monocotyledons. Pp. 211–214 in B. D. Sharma, S. Karthikeyan & N. P. Singh (editors), *Flora of Maharashtra State*. Botanical Survey of India, Calcutta.

Mayo, S. J., J. Bogner & P. C. Boyce. 1997. *The Genera of Araceae*. Royal Botanic Gardens, Kew, Richmond.

Mishra, D. K. & N. P. Singh. 2001. *Endemic and Threatened Flowering Plants of Maharashtra*. Botanical Survey of India, Calcutta.

Murata, J. 1984. An attempt at an infrageneric classification of the genus *Arisaema* (Araceae). *J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot.* 13: 431–482.

———. 1990. Present status of *Arisaema* systematics. *Bot. Mag. (Tokyo)* 103: 371–382.

Punekar, S. A. & K. P. N. Kumaran. 2005. Endemism in flora of North Western Ghats and Konkan region of India: An overview. Abstract. XV Annual Conference of Indian Association for Angiosperm Taxonomy (IAAT) and National Seminar on Emerging Trends in Plant Taxonomy, October 20–21: 93–95. Department of Botany, R.T.M. Nagpur University, Nagpur.

Sardesai, M. M., S. P. Gaikwad & S. R. Yadav. 2006. A new variety of *Arisaema sahyadricum* Yadav et al. (Araceae) from Western Ghats of Maharashtra. *Rheedea* 16: 45–47.

Sasikala, K. 2000. *A Taxonomic Revision of the Indian Araceae*. Ph.D. Thesis, Bharathiar University, Coimbatore.

Sivadasan, M. 1982. *Taxonomic Study of Araceae of South India*. Ph.D. Thesis, University of Calicut, Kerala.

Tetali, P., S. A. Punekar & P. Lakshminarasimhan. 2004. A new variety of *Arisaema* (Araceae) from Western Ghats of India. *Kew Bull.* 59: 483–487.

Yadav, S. R., K. S. Patil & M. P. Bachulkar. 1993. *Arisaema sahyadricum* (Araceae), a new species from India. *Willdenowia* 23: 177–179.

———, ——— & M. K. Janarthanam. 1997 [1998]. A new species of *Arisaema* (Araceae) from Western Ghats of South India. *Aroideana* 20: 53–56.